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(54) **HEAT EXCHANGER WITH AN INTEGRATED TANK AND HEAD SHEET**

WÄRMETAUSCHER MIT INTEGRIERTER ENDKAMMER UND ENDPLATTE

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(56) References cited:
EP-A- 0 564 761
EP-A- 0 844 035
DE-A- 3 937 463
DE-A- 4 334 203
US-A- 5 408 843
US-A- 5 460 026
US-A- 5 666 840
US-A- 5 737 952

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Description

BACKGROUND AND SUMMARY OF THE INVENTION

[0001] The present invention relates to heat exchangers having a core of cooling tubes with a tank at each end of the core and in particular to a heat exchanger in which the core tubes are directly joined to the tank without an intermediate head sheet.

[0002] Typical liquid to air heat exchangers, such as automotive radiators, include a core assembly of a plurality of cooling tubes with fins. The cooling tubes extend between spaced head sheets or header plates. The end of the tubes extend through apertures in the head sheets and are sealed thereto, typically by brazing. A tank formed as a three dimensional stamped metal body or a molded plastic body having an open side, is joined to each of the head sheets and sealed thereto to form a closed tank at each end of the core. Fluid flows from one tank through the cooling tubes to the other tank. A second fluid, typically air, passes between the fins to remove heat from the cooling tubes and thereby cool the fluid in the tubes as it flows from one tank to the other.

[0003] The seal between each tank and the head sheet is difficult to properly form and can be the source of leaks during the use of the heat exchanger. Accordingly, it is an object of the invention to provide an improved heat exchanger construction that overcomes the problems associated with the sealing of the core head sheet to the tank

[0004] U.S. Patent 5,408,843 to Lukes et al. shows a liquid cooled condenser in conjunction with a lower temperature radiator so as to provide condensed refrigerant to an evaporator. The apparatus and method for making the heat exchanger are conventional. While the disclosure teaches the use of a coolant port 62 In the lower tank and a coolant port 66 in the upper tank, there is no disclosure for how the ports are made nor a suggestion for the use of an integrally formed port from the side of the header to eliminate a leak path.

[0005] U.S. Patent No. 5,737,952 to Baumann discloses a hydroformed tubular member that is formed into a heat exchanger header. The pressure disclosed In the specification is incapable of integrally forming a port that extends from the side of the header.

[0006] German Patent No. DE 3937463 A1 to Dany teaches a vehicle radiator which employs a separate tube plate. The plate is engaged or bonded to a separate header chamber. The plate is not integrally formed with the header chamber and there is no disclosure for how to form the ports. This disclosure does not eliminate a leak path.

[0007] U.S. Patent No. 5,666,840 is drawn to a method and apparatus for piercing a pair of aligned holes through both sides of a tube combined with the process of hydroforming the tube to a final shape. The disclosure does not teach how to form a port extending from and integrally formed with the side of the header and thus does not address the problem of reducing the number of leak paths in a radiator.

[0008] Thus, none of these patents teaches a low cost hydroformed radiator that utilizes a port integrally formed from the elongated hollow body to eliminate a leak path.

[0009] The present invention overcomes the problems in the prior art by forming the tank and head sheet as an integral, single piece body. A closed tank is formed with apertures along one side for receiving the cooling tubes. The tubes are then inserted directly into the tank. This eliminates the need for a separate head sheet and the need to seal the separate head sheet to the tank. The tubes are sealed to the tank by brazing, in a conventional manner, for constructing a heat exchanger.

[0010] The heat exchanger tanks are shaped by a hydroforming process in which an elongated tubular blank is first placed in a die cavity that matches the tank s desired shape. The interior of the tubular blank is sealed and then highly pressurized with a fluid, such as water or oil, so that its outer surface is forced to take the shape of the cavity.

[0011] The hydroforming cavity includes inwardly projecting chisel points or punches. After the tube assumes the cavity shape the punches are actuated and pierce the tank.

[0012] During hydroforming, outwardly projecting ribs are formed between each of the cooling tube receiving apertures to stiffen the tank. These ribs extend in a circumferential direction relative to the tube longitudinal axis. Cylindrical projections from the tube are also formed during hydroforming. These projections form inlet and outlet necks for the tanks. During hydroforming, the cylindrical projections have closed ends. These ends are later removed, forming the open cylindrically shaped necks.

[0013] The open end or ends of the tube blank are closed with an end cap after the tank is hydroformed. The end caps are sealed to the tank by brazing.

[0014] An auxiliary oil cooler can be disposed in one of the tanks. The inlet and outlet tubes of the auxiliary cooler extend through one of the tank end caps. The end cap at the opposite end of the tank can be shaped to form a support ledge for supporting the end of the auxiliary cooler. The fluid in the oil cooler is cooled by the first fluid which is typically water or a mixture of antifreeze and water. Alternatively, the auxiliary oil cooler can be attached to one of the tanks and the other of the tanks to provide structural support thereto and to permit the auxiliary oil cooler to be cooled by a second fluid, such as air.

[0015] During hydroforming, outwardly or inwardly extending protrusions can also be formed on the tank to locate the heat exchanger on a rubber mount when attaching the heat exchanger to a supporting structure. The protlusion is typically disposed into a groove in the rubber mount The rubber mount isolates the heat exchanger from vibration of the support structure, such as

an automobile.

[0016] Further objects, features and advantages of the invention will become apparent from a consideration of the following description and the appended claims when taken in connection with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017]

FIG. 1 is a prospective view of a radiator tank constructed according to the present invention;
FIG. 2 is a sectional view of the heat exchanger tank as seen from substantially the line 2-2 in FIG. 1;
FIG. 3 is an enlarged sectional view of the circled portion of FIG. 2;
FIG. 4 is an enlarged sectional view of an alternative embodiment of the circled portion in FIG.2
FIG. 5 is a sectional view of a heat exchanger having two tanks and cooling tubes therebetween;
FIG. 6 is a side elevational view of an inlet/outlet to the radiator tank;
FIG. 7 is sectional view of a tank having an auxiliary oil cooler therein;
FIG. 8 is an enlarged sectional view of an alternative embodiment of the circled portion in FIG. 2;
FIG. 9 is a side elevational view of an overflow protrusion to the radiator tank;
FIG. 10 is a side elevational view of a radiator cap protrusion for the radiator tank;
FIG. 11 is a side elevational view of a radiator cap protrusion and radiator fill elbow for the radiator tank;
FIG. 12 is a sectional view of a heat exchanger having an auxiliary cooler connecting the top tank to the lower tank;
FIG. 13 is a side view of FIG. 12;
FIG. 14 is an enlarged cross-sectional view of the tubular support with a turbulator; and
FIG. 15 is an enlarged cross-sectional view of the tubular support with dimples.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0018] In reference to FIG. 1, a heat exchanger tank 10 is shown which is made according to the present invention. The tank 10 has a generally tubular body and is shaped by a hydroforming operation. A tubular blank is placed between a pair of dies that close over the tube to create a sealed cavity. The surface of the die cavity matches the desired final shape of the tank 10. The interior of the tubular blank is sealed and highly pressurized with a fluid, such as water or oil, so that its outer surface is forced to take the shape of the cavity. The tank 10 has ends 12 and 14. Both of the ends are open. The hydroforming liquid is introduced into the tubular blank through the open ends. During the hydroforming process, an inlet/outlet 16 is formed which projects or extends from the side of the tank. The tank side portion 18 is generally flat in the preferred embodiment.

[0019] A plurality of chisel points are mounted into the die cavity tool. After the hydroforming operation, the chisel points pierce the tank forming, a plurality of cooling tube apertures 20 in the tank side portion 18. The apertures 20 can be made of any suitable shape including round, oval or any of the variety of shapes used to form holes in heat exchangers or which could be used in heat exchangers. Such apertures 20 may be formed by the use of round, oval chisel point or dog-boned chisel point punches. Additionally, the apertures 20 may also be formed with a punch which includes a ferrule form and lead-in to assist in the assembly of tubular core members into the head tank. With reference to FIG. 3, a cooling tube aperture 20 is shown in greater detail. As a result of the chisel point pierce operation, the aperture is surrounded by an upstanding ferrule 22. The upstanding ferrule 22 provides a relatively large surface area 24 for contact with a cooling tube that is subsequently inserted into the hole 20. An alternative embodiment of the ferrule is shown in FIG. 4. There a 3-sided punch is used which forms an upstanding slug 26 to one side of the aperture 20.

[0020] Between adjacent tube apertures 20, an outward projecting rib 27 is formed. The ribs extend in a circumferential direction transverse to the tube length to stiffen the tank, and provide a tube lead in for assembly.

[0021] With reference to FIG. 6, an inlet/outlet 16 is formed during the hydroforming process. The inlet/outlet neck 16 has a closed end portion 28 which may be formed hemispherically as shown in FIG. 6. The closed end portion 28 is removed by cutting the inlet/outlet along the line 30, thereby creating an open end on the inlet/outlet. A raised rib 32 around the neck assists in retaining a hose on the neck. Identically shaped tanks can be used on both ends of the core. On one tank, the neck 16 will be the heat exchanger inlet. On the other tank, it will be the heat exchanger outlet. Both tanks can be made with the same hydroform die An assembled heat exchanger is shown in greater detail in FIG. 5. A pair of identical tanks 10 are shown spaced from one another. The tanks are oriented with their two flats side positions 18, with the cooling tube apertures, facing each other. The ends of a plurality of cooling tubes 36 are inserted into the cooling tube apertures 20 of each tank. The tubes 36 are typically surrounded by a plurality of flat or corrugated fins 40 to assist in heat transfer from the tubes. The tubes are subsequently brazed to the tanks 10 in a furnace brazing operation in a conventional manner for manufacturing heat exchangers. This provides a sealed connection between the cooling tubes 36 and the tanks 10. The tubes can be at any cross sectional shape but are preferably flat tubes. The tube apertures 20 are correspondingly slot shaped. The slots are oriented parallel to the ribs 27, in a circumferential

direction, relative to the tank.

[0022] The tanks can be hydroformed with protrusions 34 to locate the tank on a rubber mount, etc., when mounting the heat exchanger on a support structure, such as an automobile body.

[0023] The tanks and tubes can be made of aluminum, brass, steel, stainless steel or any of a variety of metals used in heat exchangers or which could be used in heat exchangers.

[0024] With reference to FIG. 7, a tank 10 is shown sealed at the ends by a pair of end caps 42 and 44. The end caps are stamped to shape and are also clad so that they can be brazed to the tank ends. In the embodiment shown in FIG. 7, the tank houses a secondary or auxiliary oil cooler 46 used to cool engine oil or transmission oil in an automotive radiator. The auxiliary cooler has an inlet pipe 48 and an outlet pipe 50 extending through the end cap 44. The end cap 42 is stamped in a shape to form a support ledge 52 to support the distal end 54 of the auxiliary cooler. The end caps are mechanically joined to the tank by toggle locks or other metal crimping operations to hold the end caps in place during assembly and prior to the brazing process.

[0025] The heat exchanger may also include a pair of side supports 60 and 62 shown in FIG. 7. These side supports extend between the two tanks 10 and hold the tanks in place relative to one another. These side supports include an outward extending flange 64 to stiffen the side supports. However, at the ends of each side support, there is a small gap 66 in the flange. This forms a stress relief to allow the heat exchanger to expand and contract during thermal cycling.

[0026] Those skilled in the art will recognize that the tube endings 36 need not be brazed to the cooling tube apertures 20 of each tank. Alternatively, an elastomeric grommet or gasket 78 may be inserted between the tube and the apertures, as shown in FIG. 8.

[0027] The heat exchanger of the present invention provides an integrated tank and head sheet. The cooling tube apertures are formed directly into the tanks. This avoids the need for a separate head sheet connected to the cooling tubes which must subsequently be sealed to a tank. In a preferred method of manufacture of the heat exchanger, the tanks are hydroformed to the desired shape and the cooling tube receiving apertures are pierced into the tank after the hydroforming operation. The heat exchanger is subsequently assembled by inserting the cooling tubes directly to the tanks and sealing by brazing, or other joining process.

[0028] Optionally, an overflow protrusion 70 is formed in the inlet 16 of the first tank 10, as shown in FIG 9. The overflow protrusion 70 has a closed end 72 which is removed by cutting the protrusion along the line 74 thereby creating an open end in the protrusion 70. The overflow protrusion 70 can be threaded, potted with epoxy or filled with an adhesive to connect it by means of a line (not shown) which is connected to an overflow bottle (not shown).

[0029] Additionally, the first tank may be formed with a radiator cap protrusion 80 in the first tank, as shown in FIGS. 10 and 11. The radiator cap protrusion 80 has a closed end 82 and it is cut along line 74 to form an opening in the radiator cap protrusion 80. A plastic molded radiator fill elbow 83 is attached to the protrusion 80 by means of an epoxy or other suitable adhesive. A cap 85 threadably engages tangs on the radiator fill elbow 13 to cover the fill hole.

[0030] The preferred mode of practicing the present invention is directed to heat exchangers that are widely used in both mobile and industrial applications. In many applications only one hot fluid, for example, engine coolant such as anti-freeze and water, transfers its heat by means of cooling tubes to a second fluid such as air, as shown in FIG. 1. In other applications, one hot fluid typically is directed into the heat exchanger and the heat from one hot fluid is cooled by a second hot fluid, typically engine coolant. Then the second hot fluid is cooled by a third fluid such as air. The first hot fluid which is normally the hottest of all three fluids such as, for example, engine or transmission oil flows into the heat exchanger where the first hot fluid transfers its heat to a second hot fluid. The second hot fluid then is cooled by means of the cooling tubes by the third fluid, as shown in FIG. 7, which is defined herein as a serial cooling system.

[0031] In another alternative embodiment of the present invention, a parallel cooling system is defined herein as a heat exchanger that is also used in both mobile and industrial applications. For example, more than one hot fluid flows into a heat exchanger where the two hot fluids are cooled by a third fluid, as shown in FIGS. 12 through 15. For example, the first hot fluid flows into the heat exchanger and its heat is transferred by means of cooling tubes to the third fluid. A parallel cooling circuit is provided and the second hot fluid flows into a separate cooling circuit wherein the second hot fluid flows through the tubular flow member 87 which transfers its heat to the third fluid.

[0032] Thus, a secondary auxiliary fluid cooler 86, typically engine oil or transmission oil and a third fluid such as air is located adjacent to the automotive radiator, as shown in FIGS. 12 and 13. The auxiliary cooler 86 has a hollow tubular member 87 which replaces the side supports 60, 62. The hollow tubular member 87 has a passage 88 formed therein. The turbulator member 89 is inserted into the passage to cause the fluid therein to be moved by fins in the flow passage to cause the fluid to be turbulated to enhance heat transfer from the tubular member to the air as is well known in the prior art. Optionally, the turbulator can be brazed to the inner walls of the tubular member. To prevent flow bypass and to stiffen the walls of the tubular member 87. Alternatively, the hollow tubular member 87 may be formed with a number of dimples 90 which protrude into the passage 88 in an altemating pattern so as to turbulate the fluid therein as is known in the art. The ends of the hollow

tubular member are closed by end forming and then flattened to seal the ends of the tubular member 17 closed. The end forming creates an opening into which a connector 92 can be inserted. The connector is brazed to the opening in the end formed end of the tubular member 87. The hollow tubular member is relatively flat and located adjacent to one of the plurality of cooling tubes 36. The width of the tubular member can vary depending on the application requirements. However, preferably the tubular member is same width as the cooling tubes 36. The hollow tubular member 87 is fastened to the tanks 10 by means of a pair of retaining tabs 93 that are formed in the oil cooler end caps 94. The tabs 93 capture the hollow tubular member 87 between the oil cooler end caps 94 for a purpose to be described later on. On the bottom of the hollow tubular member 87 is a second pair of retainer tabs 95, which are formed in the oil cooler end cap 96. The tabs 95 are formed so as to capture the bottom end of the hollow tubular member 87. The tabs 95 are fastened to a hollow tubular member 87 by means of a brazing. A series of discontinuous braze joints also connect the hollow tubular member 87 to the cooling fins 36. The top retaining tabs 93 permit the hollow tubular member 87 to slide past the tabs 93 to permit thermal growth of the hollow tubular member. Connection of the inlet/outlet of the hollow tubular member is formed by means of the connector 92. Thus, either engine oil or transmission oil may be made to flow through the hollow tubular member and transfer heat from the oil to the ambient surrounding air. It has been found that it may be advantageous to stack several hollow tubular members adjacent to each other in order to cool the hot engine oil or transmission fluid faster or to a lower fluid temperature as is well known in the art.

[0033] The hollow tubular member 87 may also be used as a side support for the heat exchanger tanks only. In this condition, the hollow tubular member 87 is flattened at each end and the end forming process would be eliminated.

[0034] Those skilled in the art will recognize that the heat exchanger described herein can be used for multiple applications where it is desired to cool hot fluids by means of a cooler fluid. Thus, the present invention can be used in applications such as charged cooled air-to-air coolers, industrial heat exchangers or radiators, to name just a few applications. The heat exchanger can also be used in refrigeration units, as a chiller. Alternatively, the heat exchanger may be used to cool air or other fluids.

Claims

1. A heat exchanger having a first tank (10) having a fluid inlet (16) and a second tank (10') having a fluid outlet (16'), a plurality of cooling tubes (36) each having a first end and a second end, said first tank being formed of an elongated hollow metal body made from a single piece and having a pair of ends, one of said pair of ends being open, said second tank being formed of an elongated hollow metal body made from a single piece and having a pair of ends, one of said pair of ends being open, the open end of said first tank and said second tank being closed by a separate end cap (42) sealingly joined to each of the hollow bodies whereby the first hollow body forms a first tank and the second hollow body forms a second tank, each of said first and second tanks having a plurality of tube receiving apertures (20) in said first tank (10), the second end of said plurality of cooling tubes projecting through said tube receiving apertures (20') of said second tank (10'), the plurality of cooling tubes (36) being sealingly joined to said first and second tanks in a leak proof manner **characterized in that** said fluid inlet (16) extending from and integrally formed from the side of said elongated hollow metal body of said first tank (10) and said fluid outlet (16') extending from and integrally formed from the side of said elongated hollow metal body of said second tank (10') whereby a fluid can flow into said first tank (10) through the fluid inlet (16) through the cooling tubes to said second tank (10') and flow from the second tank (10') out through the fluid outlet (16').

2. The heat exchanger of Claim 1 **characterized in that** said plurality of tube receiving apertures (20) are formed by a dog-boned chisel point punch.

3. The heat exchanger of Claim 1 **characterized in that** said plurality of tube receiving apertures (20) are formed by a round punch.

4. The heat exchanger of Claim 1 **characterized in that** said plurality of tube receiving apertures (20) are formed by an oval chisel point punch.

5. The heat exchanger of Claim 1 **characterized in that** said plurality of apertures (20) are formed with a punch, said punch having a ferrule form and a lead-in.

6. The heat exchanger of Claim 1 **characterized in that** said cooling tubes are flat tubes and the tube receiving apertures are slotted apertures oriented in the first tank (10) and the second tank (10') to extend in a circumferential direction of the first tank (10) and the second tank (10') tanks.

7. The heat exchanger of Claim 1 **characterized in that** an auxiliary cooler (46) disposed in one of the first or second tanks, the auxiliary cooler (46) having an inlet (48) and outlet (50) extending through the end cap (42) in one of the first or second tanks.

8. The heat exchanger of Claim 1 **characterized in**

that a support member (62) extending between the first tank and the second tank and joined thereto to hold the first and second tanks in position relative to one another, the support member (62) having a stress relief member to relieve stress during thermal cycling of the heat exchanger (66).

9. The heat exchanger of Claim 1 **characterized in that** at least one hollow tubular member (87) adjacent to one of said plurality of cooling tubes (36) and connected to said hollow body of said first tank (10) and said hollow body of said second tank (10').

10. The heat exchanger of Claim 1 **characterized in that** said first tank (10) and said second tank (10') are formed by hydroforming.

11. The heat exchanger of Claim 9 **characterized in that** said hollow tubular member (87) having a passage.

12. The heat exchanger of Claim 1 further **characterized in that** said hollow tubular member (87) having a turbulator (89) inserted in said passage (88).

13. The heat exchanger of Claim 1 further **characterized in that** the outer periphery of said hollow tubular member (87) is dimpled.

14. A method for making a heat exchanger with a pair of elongated tubes having at least one open end, a plurality of cooling tubes (36) having a first and a second end, and placing one elongated tube into a die cavity and closing the cavity, filling the tube with a pressurized fluid to deform the tube outward into engagement with the surface of the die cavity, to form a hollow elongated body, forming tube receiving apertures (20) along one side portion (18) of the hollow body while the hollow body is in the die cavity;

characterized in the method of:

forming a projection member (18) extending from and integrally formed with the side of the hollow elongated body while the hollow body is in the die cavity to form a leak proof joint;
forming tube receiving apertures (20) in the tube along one side portion of the one elongated tube (18) while the tube is in the die cavity;
removing the hollow elongated body from the die cavity;
closing the open end with an end cap to form a tank (10);
forming a second tank (10') with the other elongated tube by repeating the above steps;
inserting the first end of each cooling tube (36) into the tube receiving apertures (20) of said first tank (10); and
inserting the second end of each cooling tube (36) into the tube receiving apertures (20') of said second tank (10').

15. A method as claimed in Claim 14 **characterized in that** said tube receiving apertures (20) are formed using a dog-boned chisel point punch.

16. A method as claimed in Claim 14 **characterized in that** said tube receiving apertures (20) are formed using a round punch.

17. A method as claimed in Claim 14 **characterized in that** said tube receiving apertures (20) are formed using an oval chisel point punch.

18. A method as claimed in Claim 14 **characterized in that** said tube receiving apertures (20) are formed with a punch, said punch having a ferrule form and a lead-in.

19. A method as claimed in Claim 14 **characterized in that** said aperture forming step includes a chisel point punch operation.

20. A method as claimed in Claim 14 **characterized in that** said aperture forming step includes forming an upstanding slug (26) to one side of the aperture (20).

21. A method as claimed in Claim 14 **characterized in that** said cooling tubes (36) are flat tubes and the tube receiving apertures (20) are slotted apertures (20) oriented in the first tank (10) and the second tank (10') to extend in a circumferential direction of the first and second tanks.

22. A method as claimed in Claim 14 **characterized in that** connecting the first tank (10) and second tank (10') with a support member (62) extending therebetween and holding the first and second tanks in position relative to one another, the support member (62) having a stress relief member to relieve stress during thermal cycling of the heat exchanger (66).

23. A method as claimed in Claim 14 **characterized in that** disposing an auxiliary cooler (46) in the first or second tanks, the auxiliary cooler (46) having an inlet and outlet through the end cap.

24. A method as claimed in Claim 14 **characterized in that** said tube forming step includes hydroforming.

25. A method as claimed in Claim 14 **characterized in that** connecting a hollow member to said first tank (10) and second tank (10') and adjacent to one of said plurality of cooling tubes (36).

26. A method as claimed in Claim 14 **characterized in that** said aperture forming step includes a chisel point punch operation, said chisel point punch operation forms an upstanding ferrule (22).

27. A method as claimed in Claim 14 **characterized in that** said aperture forming step includes forming an upstanding slug (26) to one side of the aperture (20).

28. A method as claimed in Claim 14 **characterized in that** connecting a hollow tubular member (97) to said first tank (10) and second tank (10') and adjacent to one of said plurality of cooling tubes (36), said hollow member having a passage (88).

29. A method as claimed in Claim 14 **characterized in that** connecting a hollow tubular member to said first tank (10) and said second tank (10'), the outer periphery of said hollow tubular member (87) is dimpled.

30. A method as claimed in Claim 14 **characterized in that** connecting a hollow tubular member (87) to said first tank (10) and said second tank (10'), said hollow tubular member (87) having a passage (88) and a turbulator (89) in said passage (88).

Patentansprüche

1. Wärmetauscher, der einen ersten Tank (10) mit einem Fluideinlaß (16) und einen zweiten Tank (10') mit einem Fluidauslaß (16') und eine Mehrzahl von Kühlröhren (36), die jeweils ein erstes Ende und ein zweites Ende haben, aufweist, wobei der erste Tank aus einem länglichen hohlen Metallkörper, der aus einem einzelnen Stück gemacht ist und ein Paar von Enden aufweist, geformt ist, wobei ein Ende aus dem Paar von Enden offen ist, und der zweite Tank aus einem länglichen hohlen Metallkörper, der aus einem einzelnen Stück gemacht ist und ein Paar von Enden aufweist, geformt ist, wobei ein Ende aus dem Paar von Enden offen ist, wobei das offene Ende des ersten Tankes und das offene Ende des zweiten Tankes durch eine separate Endkappe (42), die dichtend mit dem jeweiligen der hohlen Körper verbunden ist, geschlossen sind, wodurch der erste hohle Körper einen ersten Tank bildet und der zweite hohle Körper einen zweiten Tank bildet, wobei der erste und der zweite Tank jeweils eine Mehrzahl von Röhrenempfangsöffnungen (20) aufweisen, in dem ersten Tank, wobei das zweite Ende der Mehrzahl von Kühlröhren durch die Röhrenempfangsöffnungen (20') in dem zweiten Tank (10') vorstehen, wobei die Mehrzahl der Kühlröhren (36) dichtend mit den ersten und zweiten Tanks in einer leckdichten Weise verbunden ist, **dadurch gekennzeichnet, daß** der Fluideinlaß (16) sich von der Seite des länglichen hohlen Metallkörpers des ersten Tankes (10) erstreckt und integral mit der Seite ausgebildet ist und der Fluideinlaß (16') sich von der Seite des länglichen hohlen Metallkörpers des zweiten Tanks (10') erstreckt und integral mit der Seite ausgebildet ist, wodurch ein Fluid in den ersten Tank (10) durch den Fluideinlaß (16) und durch die Kühlröhren in den zweiten Tank (10') strömen und aus dem zweiten Tank (10') durch den Fluidauslaß (16') ausströmen kann.

2. Wärmetauscher nach Anspruch 1, **dadurch gekennzeichnet, daß** die Mehrzahl der Röhrenempfangsöffnungen (20) durch einen Hundeknochenform-Meißelpunktstempel ausgebildet sind.

3. Wärmetauscher nach Anspruch 1, **dadurch gekennzeichnet, daß** die Mehrzahl der Röhrenempfangsöffnungen (20) durch einen runden Stempel ausgebildet sind.

4. Wärmetauscher nach Anspruch 1, **dadurch gekennzeichnet, daß** die Mehrzahl der Röhrenempfangsöffnungen (20) durch einen ovalen Meißelpunktstempel ausgebildet sind.

5. Wärmetauscher nach Anspruch 1, **dadurch gekennzeichnet, daß** die Mehrzahl der Öffnungen (20) mit einem Stempel ausgebildet sind, wobei der Stempel eine Ringform und eine Einführungsöffnung aufweist.

6. Wärmetauscher nach Anspruch 1, **dadurch gekennzeichnet, daß** die Kühlröhren flache Röhren sind und die Röhrenempfangsöffnungen geschlitzte Öffnungen sind, die in dem ersten Tank (10) und dem zweiten Tank (10') so orientiert sind, daß sie sich in einer Umfangsrichtung des ersten Tanks (10) und des zweiten Tanks (10') erstrecken.

7. Wärmetauscher nach Anspruch 1, **dadurch gekennzeichnet, daß** ein Hilfskühler (46) in einem der ersten oder zweiten Tanks angeordnet ist, wobei der Hilfskühler (46) einen Einlaß (48) und einen Auslaß (50) aufweist, die sich durch die Endkappe (42) in einem der ersten oder zweiten Tanks erstrekken.

8. Wärmetauscher nach Anspruch 1, **dadurch gekennzeichnet, daß** sich ein Halteteil (62) zwischen dem ersten Tank und dem zweiten Tank erstreckt und mit diesem zum Halten des ersten und des zweiten Tanks in Position relativ zueinander verbunden ist, wobei das Halteteil (62) ein Spannungsentspannungsteil aufweist, um Spannung während eines thermischen Zyklus des Wärmetauschers (66) zu entspannen.

9. Wärmetauscher nach Anspruch 1, **dadurch gekennzeichnet, daß** mindestens ein hohles röhrenförmiges Teil (87) benachbart zu einer aus der Mehrzahl der Kühlröhren (36) und verbunden mit dem hohlen Körper des ersten Tanks (10) und dem hohlen Körper des zweiten Tanks (10') ist.

10. Wärmetauscher nach Anspruch 1, **dadurch gekennzeichnet, daß** der erste Tank (10) und der zweite Tank (10') durch Hydroformen ausgebildet sind.

11. Wärmetauscher nach Anspruch 1, **dadurch gekennzeichnet, daß** das hohle röhrenförmige Teil (87) einen Durchgang aufweist.

12. Wärmetauscher nach Anspruch 1, weiter **dadurch gekennzeichnet daß** das hohle röhrenförmige Teil (87) einen Turbulenzerzeuger (89), der in den Durchgang (88) eingesetzt ist, aufweist.

13. Wärmetauscher nach Anspruch 1, weiter **dadurch gekennzeichnet, daß** der äußere Umfang des hohlen röhrenförmigen Teils (87) mit Vertiefungen versehen ist.

14. Verfahren zum Bilden eines Wärmetauschers mit einem Paar von länglichen Röhren, die mindestens ein offenes Ende aufweisen, und einer Mehrzahl von Kühlröhren (36), die ein erstes und ein zweites Ende aufweisen, und Plazieren einer länglichen Röhre in einem Formwerkzeughohlraum und Schließen des Hohlraums, Füllen der Röhre mit einem unter Druck gesetzten Fluid zum Deformieren der Röhre nach außen in einen Eingriff mit der Oberfläche des Formwerkzeughohlraums zum Bilden eines hohlen länglichen Körpers, Bilden von Röhrenempfangsöffnungen (20) entlang eines Seitenabschnitts (18) des hohlen Körpers, während der hohle Körper in dem Formwerkzeughohlraum ist, wobei das Verfahren **gekennzeichnet ist durch**:

Bilden eines Vorsprungsteils (18), das sich von der Seite des hohlen länglichen Körpers erstreckt und integral mit der Seite ausgebildet ist, während der hohle Körper in dem Formwerkzeughohlraum ist, um eine leckdichte Verbindung auszubilden;
Bilden der Röhrenempfangsöffnungen (20) in der Röhre entlang eines Seitenabschnittes der einen länglichen Röhre (18), während die Röhre in dem Formwerkzeughohlraum ist;
Entfernen des hohlen länglichen Körpers aus dem Formwerkzeugshohlraum;
Schließen des offenen Endes mit einer Endkappe zur Bildung eines Tanks (10);
Bilden eines zweiten Tanks (10') mit der anderen länglichen Röhre **durch** Wiederholen der obigen Schritte;
Einsetzen des ersten Endes von jeder Kühlröhre (36) in die Röhrenempfangsöffnungen (20) des ersten Tanks (10); und
Einsetzen des zweiten Endes jeder Kühlröhre (36) in die Röhrenempfangsöffnungen (20') des zweiten Tanks (10').

15. Verfahren nach Anspruch 14, **dadurch gekennzeichnet, daß** die Röhrenempfangsöffnungen (20) unter Verwendung eines Hundeknochenform-Meißelpunktstempels ausgebildet werden.

16. Verfahren nach Anspruch 14, **dadurch gekennzeichnet, daß** die Röhrenempfangsöffnungen (20) unter Verwendung eines runden Stempels ausgebildet werden.

17. Verfahren nach Anspruch 14, **dadurch gekennzeichnet, daß** die Röhrenempfangsöffnungen (20) unter Verwendung eines ovalen Meißelpunktstempels ausgebildet werden.

18. Verfahren nach Anspruch 14, **dadurch gekennzeichnet, daß** die Röhrenempfangsöffnungen (20) mit einem Stempel ausgebildet werden, wobei der Stempel eine Ringform und eine Einführungsöffnung aufweist.

19. Verfahren nach Anspruch 14, dadurch die gekennzeichnet, daß der Öffnungsausbildungsschritt einen Meißelpunktstempelvorgang enthält.

20. Verfahren nach Anspruch 14, **dadurch gekennzeichnet, daß** der Öffnungsbildungsschritt das Bilden eines hochstehenden Ansatzes (26) auf einer Seite der Öffnung (20) enthält.

21. Verfahren nach Anspruch 14, **dadurch gekennzeichnet, daß** die Kühlröhren (36) flache Röhren sind und die Röhrenempfangsöffnungen (20) geschlitzte Öffnungen (20) sind, die in dem erste Tank (10) und dem zweiten Tank (10') so orientiert sind, daß sie sich in einer Umfangsrichtung des ersten und des zweiten Tanks erstrecken.

22. Verfahren nach Anspruch 14, **gekennzeichnet durch** ein Verbinden des ersten Tanks (10) und des zweiten Tanks (10') mit einem Halteteil (62), das sich zwischen diesen erstreckt und den ersten und den zweiten Tank in Position relativ zueinander hält, wobei das Halteteil (62) ein Spannungsentspannungsteil zum Entspannen von Spannung während eines thermischen Zyklus des Wärmetauschers (66) aufweist.

23. Verfahren nach Anspruch 14, **gekennzeichnet**

durch ein Anordnen eines Hilfskühlers (46) in dem ersten oder zweiten Tank, wobei der Hilfskühler (46) einen Einlaß und einen Auslaß **durch** die Endkappe aufweist.

24. Verfahren nach Anspruch 14, **dadurch gekennzeichnet, daß** der Röhrenformungsschritt ein Hydroformen enthält.

25. Verfahren nach Anspruch 14, **gekennzeichnet durch** ein Verbinden eines hohlen Teils mit dem ersten Tank (10) und dem zweiten Tank (10') und benachbart zu einer aus der Mehrzahl der Kühlröhren (36).

26. Verfahren nach Anspruch 14, **dadurch gekennzeichnet, daß** der Öffnungsbildungsschritt einen Meißelpunktstempelvorgang enthält, wobei der Meißelpunktstempelvorgang einen hochstehenden Ring (22) bildet.

27. Verfahren nach Anspruch 14, **dadurch gekennzeichnet, daß** der Öffnungsbildungsschritt das Bilden eines hochstehenden Ansatzes (26) auf einer Seite der Öffnung (20) enthält.

28. Verfahren nach Anspruch 14, **gekennzeichnet durch** ein Verbinden eines hohlen röhrenförmigen Teils (97) mit dem ersten Tank (10) und dem zweiten Tank (10') und benachbart zu einer aus der Mehrzahl der Kühlröhren (36), wobei das hohle Teil einen Durchgang (88) aufweist.

29. Verfahren nach Anspruch 14, **gekennzeichnet durch** ein Verbinden eines hohlen röhrenförmigen Teils mit dem ersten Tank (10) und dem zweiten Tank (10'), wobei der äußere Umfang des hohlen röhrenförmigen Teils (87) mit Vertiefungen versehen ist.

30. Verfahren nach Anspruch 14, **gekennzeichnet durch** ein Verbinden eines hohlen röhrenförmigen Teils (87) mit dem ersten Tank (10) und dem zweiten Tank (10'), wobei das hohle röhrenförmige Teil (87) einen Durchgang (88) und einen Turbulenzerzeuger (89) in dem Durchgang (88) aufweist.

Revendications

1. Echangeur de chaleur comprenant un premier réservoir (10) comportant un orifice d'entrée de fluide (16) et un deuxième réservoir (10') comportant un orifice de sortie de fluide (16'), une pluralité de tubes de refroidissement (36) comportant chacun une première extrémité et une deuxième extrémité, ledit premier réservoir étant constitué par un corps métallique creux allongé réalisé d'une seule pièce et comportant une paire d'extrémités, l'une de ladite paire d'extrémités étant ouverte, ledit deuxième réservoir étant constitué par un corps métallique creux allongé réalisé d'une seule pièce et comportant une paire d'extrémités, l'une de ladite paire d'extrémités étant ouverte, les extrémités ouvertes dudit premier réservoir et dudit deuxième réservoir étant fermées par un capuchon d'extrémité séparé (42) réuni de façon étanche à chacun des corps creux, grâce à quoi le premier corps creux forme un premier réservoir et le deuxième corps creux forme un deuxième réservoir, chacun desdits premier et deuxième réservoirs comportant une pluralité d'ouvertures de réception de tube (20) dans ledit premier réservoir (10), la deuxième extrémité de ladite pluralité de tubes de refroidissement faisant saillie à travers lesdites ouvertures de réception de tube (20') dudit deuxième réservoir (10'), la pluralité de tubes de refroidissement (36) étant réunie de façon étanche auxdits premier et deuxième réservoirs d'une façon étanche vis-à-vis des fuites, **caractérisé en ce que** ledit orifice d'entrée de fluide (16) s'étend à partir du côté dudit corps métallique creux allongé dudit premier réservoir (10) et est formé d'une seule pièce avec celui-ci et **en ce que** ledit orifice de sortie de fluide (16') s'étend à partir du côté dudit corps métallique creux allongé dudit deuxième réservoir (10') et est formé d'une seule pièce avec celui-ci, grâce à quoi un fluide peut s'écouler à l'intérieur dudit premier réservoir (10), à travers l'orifice d'entrée de fluide (16), à travers les tubes de refroidissement, vers ledit deuxième réservoir (10'), et s'écouler hors du deuxième réservoir (10') à travers l'orifice de sortie de fluide (16').

2. Echangeur de chaleur selon la revendication 1, **caractérisé en ce que** ladite pluralité d'ouvertures de réception de tube (20) sont formées à l'aide d'un poinçon à pointe de ciseau en os de chien.

3. Echangeur de chaleur selon la revendication 1, **caractérisé en ce que** ladite pluralité d'ouvertures de réception de tube (20) sont formées à l'aide d'un poinçon rond.

4. Echangeur de chaleur selon la revendication 1, **caractérisé en ce que** ladite pluralité d'ouvertures de réception de tube (20) sont formées à l'aide d'un poinçon à pointe de ciseau ovale.

5. Echangeur de chaleur selon la revendication 1, **caractérisé en ce que** ladite pluralité d'ouvertures (20) sont formées à l'aide d'un poinçon, ledit poinçon ayant une forme de virole et une ouverture.

6. Echangeur de chaleur selon la revendication 1, **caractérisé en ce que** lesdits tubes de refroidissement sont des tubes plats et **en ce que** les ouver-

tures de réception de tube sont des ouvertures à encoches orientées dans le premier réservoir (10) et dans le deuxième réservoir (10') de façon à s'étendre dans une direction circonférentielle par rapport au premier réservoir (10) et au deuxième réservoir (10').

7. Echangeur de chaleur selon la revendication 1, **caractérisé en ce qu**'un dispositif de refroidissement auxiliaire (46) est disposé dans l'un des premier ou deuxième réservoirs, le dispositif de refroidissement auxiliaire (46) comportant un orifice d'entrée (48) et un orifice de sortie (50) s'étendant à travers le capuchon d'extrémité (42) dans l'un des premier ou deuxième réservoirs.

8. Echangeur de chaleur selon la revendication 1, **caractérisé en ce qu**'un élément de support (62) s'étend entre le premier réservoir et le deuxième réservoir et est réuni à ceux-ci pour maintenir les premier et deuxième réservoirs en position l'un par rapport à l'autre, l'élément de support (62) comportant un élément de relâchement des contraintes pour relâcher les contraintes durant les cycles thermiques de l'échangeur de chaleur (66).

9. Echangeur de chaleur selon la revendication 1, **caractérisé en ce qu**'au moins un élément tubulaire creux (87) est adjacent à l'un de ladite pluralité de tubes de refroidissement (36) et est raccordé audit corps creux dudit premier réservoir (10) et dudit corps creux dudit deuxième réservoir (10').

10. Echangeur de chaleur selon la revendication 1, **caractérisé en ce que** ledit premier réservoir (10) et ledit deuxième réservoir (10') sont formés par hydroformage.

11. Echangeur de chaleur selon la revendication 9, **caractérisé en ce que** ledit élément tubulaire creux (87) comporte un passage.

12. Echangeur de chaleur selon la revendication 1, caractérisé de plus en ce que ledit élément tubulaire creux (87) comporte un dispositif de turbulences (89) inséré dans ledit passage (88).

13. Echangeur de chaleur selon la revendication 1, caractérisé de plus en ce que la périphérie extérieure dudit élément tubulaire creux (87) est bosselée.

14. Procédé pour réaliser un échangeur de chaleur avec une paire de tubes allongés comportant au moins une extrémité ouverte, une pluralité de tubes de refroidissement (36) comportant une première et une deuxième extrémités, et permettant de disposer un tube allongé à l'intérieur d'une cavité de matrice et de fermer la cavité, de remplir le tube avec un fluide sous pression pour déformer le tube vers l'extérieur en contact avec la surface de la cavité de matrice de façon à former un corps allongé creux, de former des ouvertures de réception de tube (20) le long d'une partie latérale (18) du corps creux lorsque le corps creux se trouve dans la cavité de matrice ;

le procédé étant **caractérisé par** :

la formation d'un élément de saillie (18) s'étendant à partir du côté du corps allongé creux et formé d'une seule pièce avec celui-ci pendant que le corps creux se trouve dans la cavité de matrice, de façon à former un joint étanche vis-à-vis des fuites ;
la formation d'ouvertures de réception de tube (20) dans le tube le long d'une partie latérale du tube allongé (18) pendant que le tube se trouve dans la cavité de matrice ;
le retrait du corps allongé creux de la cavité de matrice ;
la fermeture de l'extrémité ouverte à l'aide d'un capuchon d'extrémité afin de former un réservoir (10) ;
la formation d'un deuxième réservoir (10') avec l'autre tube allongé en répétant les étapes ci-dessus ;
l'insertion de la première extrémité de chaque tube de refroidissement (36) à l'intérieur des ouvertures de réception de tube (20) dudit premier réservoir (10) ; et
l'insertion de la deuxième extrémité de chaque tube de refroidissement (36) à l'intérieur des ouvertures de réception de tube (20') dudit deuxième réservoir (10').

15. Procédé selon la revendication 14, **caractérisé en ce que** lesdites ouvertures de réception de tube (20) sont formées à l'aide d'un poinçon à pointe de ciseau en os de chien.

16. Procédé selon la revendication 14, **caractérisé en ce que** lesdites ouvertures de réception de tube (20) sont formées à l'aide d'un poinçon rond.

17. Procédé selon la revendication 14, **caractérisé en ce que** lesdites ouvertures de réception de tube (20) sont formées à l'aide d'un poinçon à pointe de ciseau ovale.

18. Procédé selon la revendication 14, **caractérisé en ce que** lesdites ouvertures de réception de tube (20) sont formées à l'aide d'un poinçon, ledit poinçon ayant une forme de virole et une ouverture.

19. Procédé selon la revendication 14, **caractérisé en ce que** ladite étape de formation d'ouvertures comprend une opération de poinçonnage par pointe de

ciseau.

20. Procédé selon la revendication 14, **caractérisé en ce que** ladite étape de formation d'ouvertures comprend la formation d'une goupille dressée vers le haut (26) sur un côté de l'ouverture (20).

21. Procédé selon la revendication 14, **caractérisé en ce que** lesdits tubes de refroidissement (36) sont des tubes plats, et **en ce que** les ouvertures de réception de tube (20) sont des ouvertures à encoches (20) orientées dans le premier réservoir (10) et dans le deuxième réservoir (10') de façon à s'étendre dans une direction circonférentielle par rapport aux premier et deuxième réservoirs.

22. Procédé selon la revendication 14, **caractérisé par** le raccordement du premier réservoir (10) et du deuxième réservoir (10') avec un élément de support (62) s'étendant entre eux, et le maintien des premier et deuxième réservoirs en position l'un par rapport à l'autre, l'élément de support (62) comportant un élément de relâchement des contraintes pour relâcher les contraintes durant les cycles thermiques de l'échangeur de chaleur (66).

23. Procédé selon la revendication 14, **caractérisé par** la disposition d'un dispositif de refroidissement auxiliaire (46) dans le premier ou le deuxième réservoirs, le dispositif de refroidissement auxiliaire (46) comportant une extrémité d'entrée et une extrémité de sortie à travers le capuchon d'extrémité.

24. Procédé selon la revendication 14, **caractérisé en ce que** ladite étape de formation de tube comprend un hydroformage.

25. Procédé selon la revendication 14, **caractérisé par** le raccordement d'un élément creux audit premier réservoir (10) et audit deuxième réservoir (10') et au voisinage de l'un de ladite pluralité de tubes de refroidissement (36).

26. Procédé selon la revendication 14, **caractérisé en ce que** ladite étape de formation d'ouvertures comprend une opération de poinçonnage par une pointe de ciseau, ladite opération de poinçonnage par une pointe de ciseau formant une virole dressée vers le haut (22).

27. Procédé selon la revendication 14, **caractérisé en ce que** ladite étape de formation d'ouvertures comprend la formation d'une goupille dressée vers le haut (26) sur un côté de l'ouverture (20).

28. Procédé selon la revendication 14, **caractérisé par** le raccordement d'un élément tubulaire creux (97) audit premier réservoir (10) et audit deuxième réservoir (10') et au voisinage de l'un de ladite pluralité de tubes de refroidissement (36), ledit élément creux comportant un passage (88).

29. Procédé selon la revendication 14, **caractérisé par** le raccordement d'un élément tubulaire creux audit premier réservoir (10) et audit deuxième réservoir (10'), la périphérie extérieure dudit élément tubulaire creux (87) étant bosselée.

30. Procédé selon la revendication 14, **caractérisé par** le raccordement d'un élément tubulaire creux (87) audit premier réservoir (10) et audit deuxième réservoir (10'), ledit élément tubulaire creux (87) comportant un passage (88) et un dispositif de turbulences (89) dans ledit passage (88).

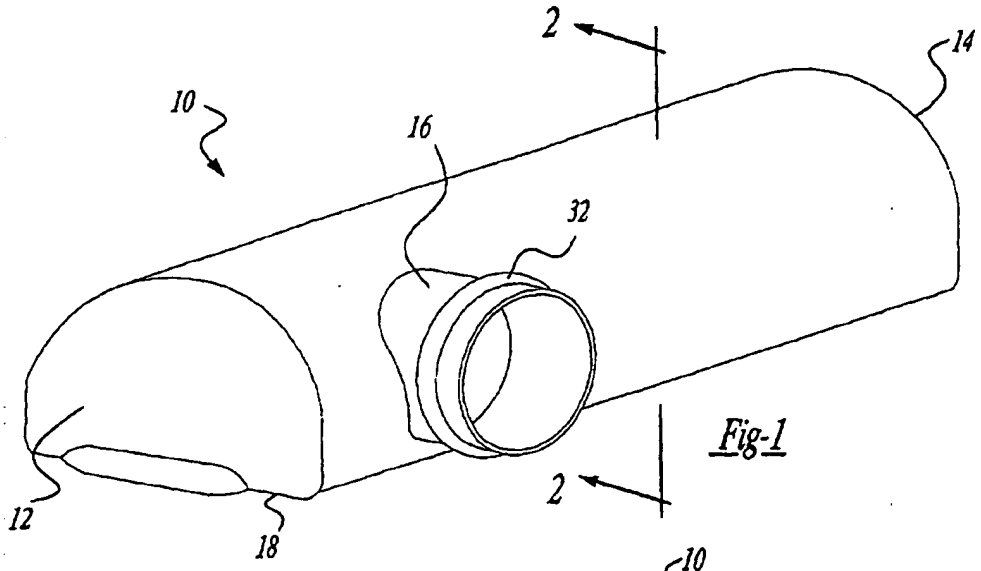


Fig-1

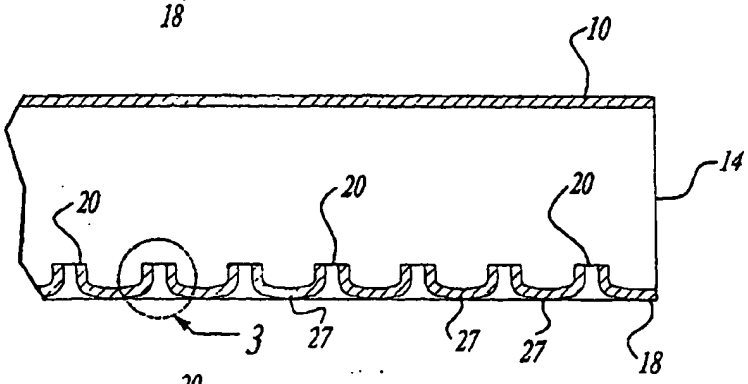
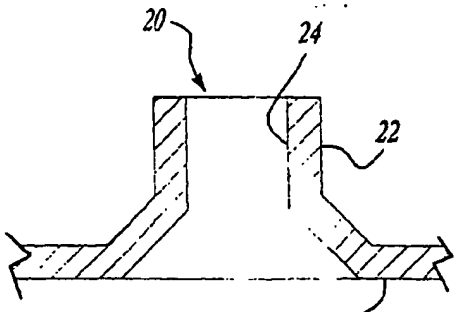


Fig-2



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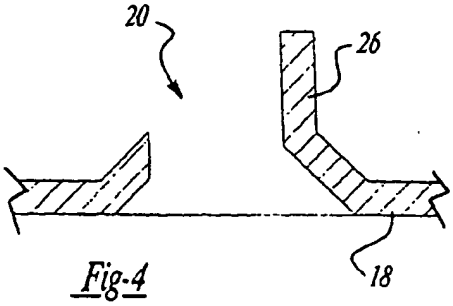

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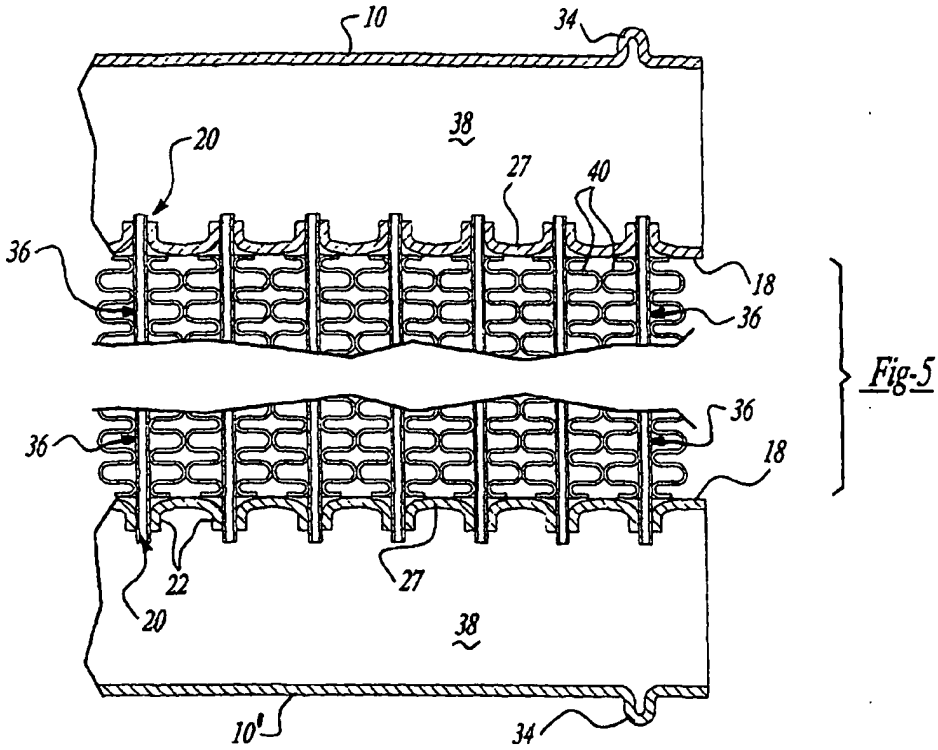

Fig-5

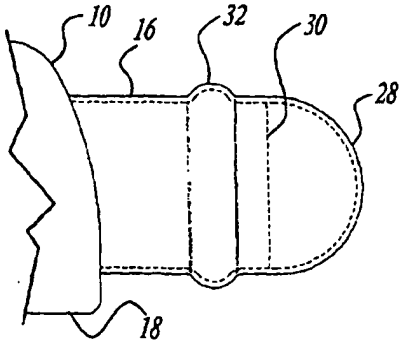

Fig-6

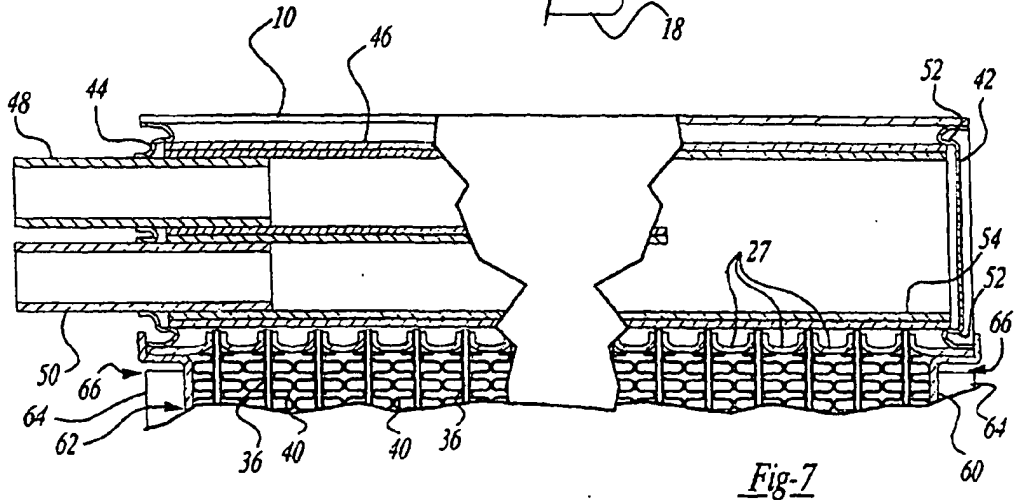

Fig-7

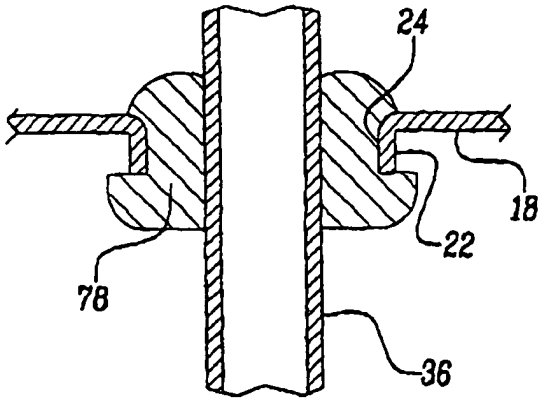

Fig-8

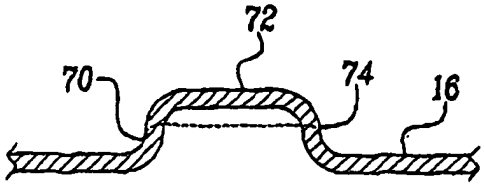

Fig-9

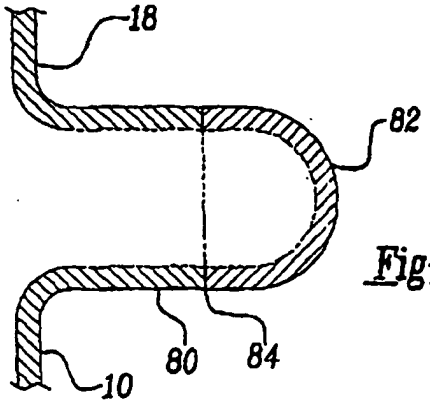

Fig-10

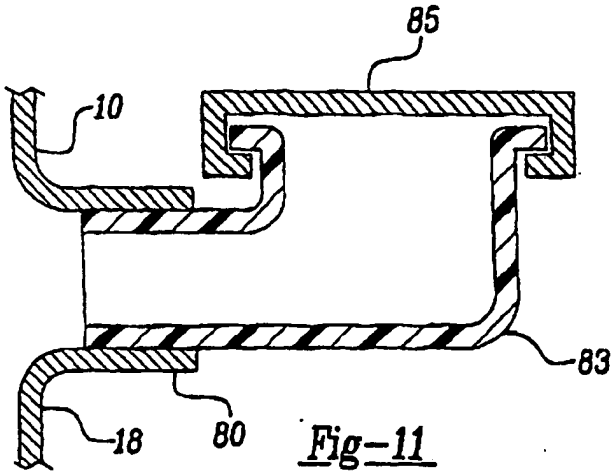

Fig-11

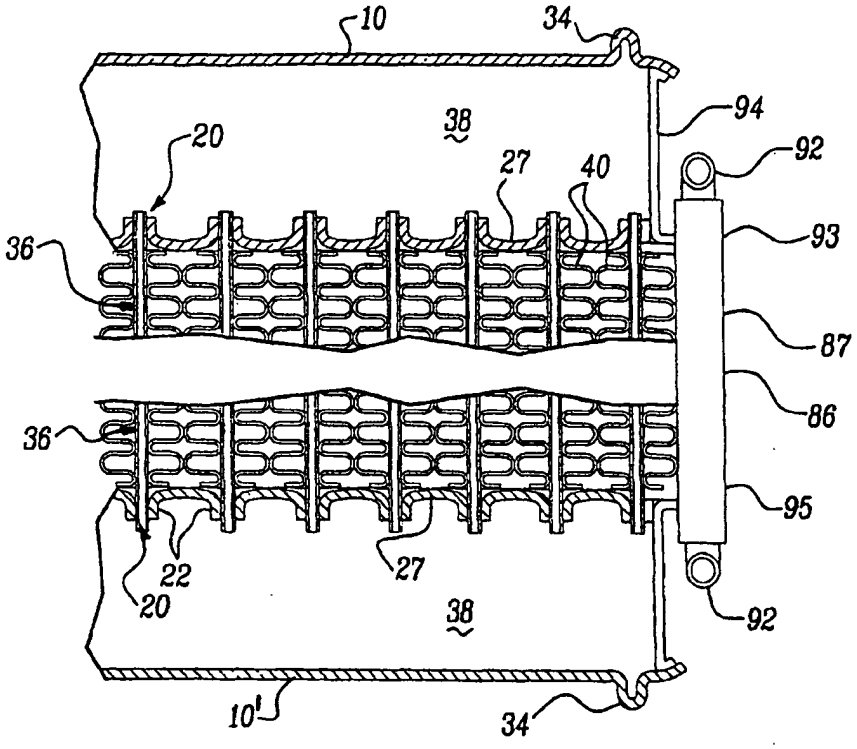

Fig-12

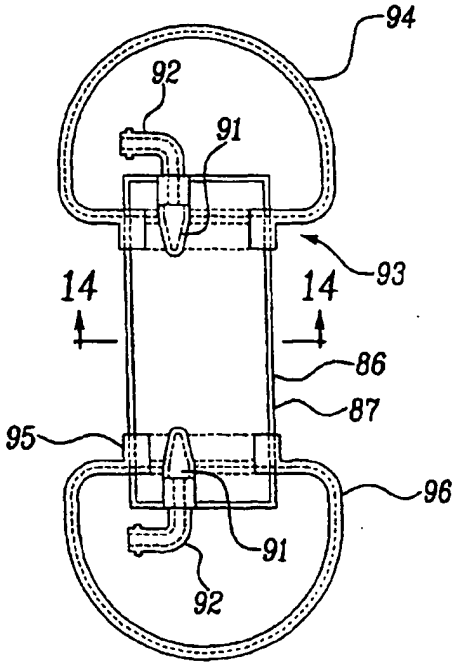

Fig-13

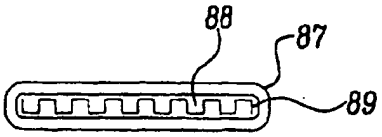

Fig-14

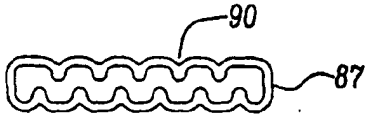

Fig-15